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ABSTRACT

This report presents ten ideas about children's learning and cognition that are based on recent research. The empirical findings are reviewed and related to educational practices. The findings concern the following topics of learning and cognition: (1) individual differences, (2) children's problem-solving abilities and ability to remember component parts of problems, (3) selective attention, (4) transfer of training, (5) distraction from tasks by irrelevant information, (6) relationships between language and abstract thought, (7) observational learning, (8) children's use of hypotheses, (9) effects of breaking down complex problems into successively more complex components, and (10) teacher-child relationships. (DP)

THE YOUNG CHILD: LEARNING AND COGNITION

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In many ways this is an opportune time to write a chapter about current research in children's learning and cognitive development as it may be related to the teaching of mathematics. The past 15 years have been productive ones for psychologists interested in questions about how children learn and think, and some of the information they have gathered should prove to be of interest to persons who face the practical problem of teaching young children.

Not too many years ago a chapter such as this would have had to be based on ideas rather than on research, on speculation rather than on observation. Psychologists in the past tended to be less interested in doing research with children than in studying learning and problem solving in lower animals and college sophomores. Today there is such an abundance of studies dealing with children that the problem is how to synthesize the most important and useful data. Literally thousands of articles have been published during the past two decades on cognitive development and children's learning.

A comprehensive picture of the research cannot be presented in a short chapter. The approach I have taken is to describe some of the major conclusions and to illustrate the basis of these conclusions with typical experiments. The reader should keep in mind that the research has been conducted in the laboratory, rather than in the classroom. There have been few efforts to evaluate these findings in teaching situations. We have reason to believe that the information is not restricted to the laboratory setting, however, and suggest that it is not too soon to try to make conscious use of this information in real-life situations.

The generalizations made in the following pages are rather well substantiated by experimental data. Some are implicit in the teaching techniques already in practice in most schools; others may be new to the awareness of educators; still others may be, or appear to be, in contradiction to assumptions underlying current teaching. It is well, whatever techniques are used, for educators to be aware of essential components of their procedures which may enhance learning.

1. <u>There are wide individual differences in children's ability to learn and to solve problems and these differences are complexly determined.</u> This appears to be an obvious statement, which most teachers would confirm, but its infallibility is basic to any consideration of children's learning. Whatever the task, however it is presented, whatever the group, children tend to learn at different speeds. There are differences in rate of acquiring a conditioned response among newborns and there are differences in rate of learning differential equations among twenty-year-olds. The pervasiveness of individual differences precludes the possibility of producing equally rapid progress by all children through any set of materials. The more we find out about individual differences, the more complex the problem seems to become.

A commonly held hypothesis about the basis of differential rates of learning is that learning ability is determined by the child's level of intelligence. Everyday experience indicates that brighter children tend to learn more rapidly, especially in the early grades. The difficulty in reaching conclusions about the relation between learning and intelligence from what goes on in classrooms is that children do not start learning with equal amounts of information and experience. The child who has a good vocabulary is more likely to be able to use language effectively in school. The child who has broad experience and can identify a large number of common objects will be able to relate this experience to his classroom studies. Because there is so much transfer from the child's everyday experience to what occurs in school, the classroom probably is not the best place to try to determine the relationship between learning and intelligence.

Perhaps a more revealing approach would be to use tasks in which there is less transfer from everyday life. This can be done with many of the materials that are used in laboratory studies. We can test children's ability to learn to associate the names of two animals, to remember the location of cards of different colors, to learn a new code, or to learn a new principle. Although differences in past experience are not eliminated, these tasks are less dependent upon what children already have learned. The results of a number of studies using such tasks have been reported. Rarely is the correlation between IQ and rate of learning in these laboratory learning and problem solving tasks more than .50. This means that intelligence is related to children's ability to learn, but that rarely is more than 25% ($\underline{r}^2$) of the variability in performance on the learning task attributable to variability in intelligence. It is not appropriate, therefore, to discuss learning and intelligence as identical functions. Many factors besides intelligence must play an important role in determining rate of learning. For example, children differ in the level of anxiety with which they enter learning situations; level of anxiety has been found to be significantly related to rate of learning. Children differ in the style with which they approach problems, some responding rapidly and impulsively, others being more cautious and reflective before offering a solution. Some learning situations require one or another approach more or less exclusively. The nature of children's motivation to achieve and their level of aspiration have been found to play an important role in determining how well they will perform in learning tasks.

It would seem, therefore, that the teacher would have to be a psychodiagnostician to comprehend all the factors that may contribute to differences in performance among children in a classroom. This is impossible, of course, but it does emphasize the importance of attending closely to the characteristics of each child, as well as to the material that the teacher is trying to present. We hear a great deal about individualized instruction; it seems to be the best response to the facts discussed thus far. On the basis of what we know about individual differences in learning it would seem that efforts should be directed increasingly at presenting materials to children that will capitalize on their individual strengths.

2. Children may fail to solve problems because they cannot remember the components of the problem. When a child is presented a simple word problem and fails to come up with the correct answer, the usual deduction is that he is incapable of making the appropriate inferences from information contained in this type of problem. In other words, he cannot solve the problem even though he understands its components. This conclusion is common among teachers and among psychologists. Piaget, for example, has made much in his theory of cognitive development of the fact that children under the ages of seven or eight are incapable of making transitive inferences. Children have been given problems of the following, familiar type: If Mary is older than Jane, and Jane is older than Sue, who is older, Mary or Sue? To solve this problem it is necessary to combine two separate pieces of information, the relation between the ages of Mary

and Jane, and the relation between the ages of Jane and Sue. From these two relations the child must infer a third relation that is not directly specified. If it is true, as Piaget holds, that young children have great difficulty in making such inferences before around the end of the first grade, we may wonder how they can comprehend elementary principles of measurement.

A recent study by Bryant and Trabasso (1971) has cast great doubt on the validity of claims that transitive inference does not occur at early development periods. They asked the important question, whether children's poor performance on inference problems is due to the fact that they are cognitively immature, or to their failure to remember the first and second relations. If the difficulty is due to problems of memory rather than of thought, it should be possible to find transitive inference at much younger ages -- if appropriate care is taken to insure that the child remembers the components of the problem.

Bryant and Trabasso used five wooden rods of different lengths (A through E in order of decreasing length). The subjects were four-, five-, and six-year-olds. The rods protruded one inch from the top of a box and were color coded. The child was asked the color of the rod that was longer (or shorter) within a pair. After he responded the rods were removed and the child could observe whether his response was correct. Training was given on four comparisons, $A > B$, $B > C$, $C > D$, and $D > E$, presented repeatedly in this fixed order or its reverse. Training continued in this manner until the child was correct eight of ten times; after this, the pairs were presented in random order until the child responded correctly on six successive comparisons. This extensive procedure was adopted to insure that the child had thoroughly learned the initial relations. Testing followed immediately. In the testing phase, each child was tested four times on the ten possible pairs of colors. Memory for the original comparison was assessed from the responses to the four original comparisons, and ability to make inferences was assessed from responses to the six other comparisons.

Transitive inference was found at all ages. Four-year-olds, for example, gave correct responses on 90% or more of the trials, except in the comparison B versus D, where they were correct on 78% of the trials.

The whole procedure was repeated with a different sample of children with one modification. Rather than allowing the children to see which of the rods was longer after each response during the training period the adult simply told them the correct answer. The results were practically identical to those of the first study.

These studies lead to an important point. Before concluding that children have failed to reach a level of cognitive development where certain types of mental operations can take place. one must be sure that more basic conditions for successful response have been met. One of these is memory of the content of the problem.

The same line of argument has been presented by Kagan and Kogan (1970). It has been asserted that children under the ages of seven or eight are incapable of performing adequately on class-inclusion problems. Typically, a problem of the following type is presented orally: "See these beads? These are all wooden beads. Some of them are brown and some of them are white. Tell me, are there more wooden beads or more brown beads?" Young children typically say that there are more brown beads. Piaget has concluded that such results are evidence that the child is unable to think simultaneously of both the whole and the parts, of classes and subclasses, and that this again is an index of cognitive immaturity. Kagan and Kogan report that when six-year-olds were asked a problem of this type orally, only 10% were able to give the correct answer. When the problem was presented in written form and all elements of the problem were available to the child as long as he wished, 70% gave the correct response. This is another example where poor performance is not a result of inadequacies in thought, but of a reduced ability to retain all the required information.

3. <u>Children may make errors because they attend to irrelevant attributes of the situation</u>. Some of the most frequently quoted examples of inadequate cognitive development are found in the responses of young children to the conservation problems developed by Piaget. The child is shown two identical beakers filled with equivalent amounts of liquid. After the child has judged the amounts to be the same, the liquid in one beaker is poured into a third, narrower beaker. The child is asked whether the two beakers now contain the same amounts of liquid. Young children typically say they do not. Their explanation is that the water level differs in the two beakers. Their judgement is based, therefore, on the attribute of height, rather than of volume. Or the child is asked to count out ten

beads and to place the beans in two parallel rows, with each bean directly opposite its counterpart in the other row. Is there the same number of beans in each row? The child concurs that there is an equal number. The beans in one row then are placed close together so they occupy a shorter length than the beans in the second row. Now are there equal numbers of beans in each row? The young child is likely to answer that there are not. Why? Because one row is longer than the other. The child appears unable to comprehend that differences in length do not produce differences in quantity.

Do results such as these mean that the child believes that variations in one dimension imply changes in a second dimension? Or are the results more economically explained by the manner in which young children deploy their attention? Could young children be taught to ignore changes in an irrelevant dimension and base their judgments on what happens to the relevant dimension? Gelman (1969) has presented evidence that they can.

From the adult's point of view only the amount of liquid is relevant in problems dealing with the conservation of liquid quantity. But on the test trials the beakers may differ in size, shape, height, and width. Gelman attempted to force children to attend to quantitative relations and ignore other attributes. Standard tests of conservation of length, number, liquid, and mass were given to five-year-olds. Only those who failed to demonstrate conservation were retained for the study. For training, children were given experience with oddity problems. In these problems the child had to select the odd stimulus in a set of three stimuli. The stimuli were carefully constructed so that on one trial there may have been two different patterns of three dots, and a still different pattern of two dots. On the next trial, there may have been five dots in a short line and two sets of four dots spread out in different arrangements. Number was the relevant dimension, and spatial configuration was irrelevant.

The oddity problems were learned relatively rapidly. The children learned to select the stimulus that was "odd" in number of elements, regardless of the spatial configuration. The children then were retested for conservation of length and number. Nearly all children showed perfect conservation. In addition, when they were retested for conservation of liquid and mass which they also had failed earlier, over half to the children demonstrated conservation. There was, therefore, both specific and generalized transfer from the oddity training. We conclude that tests of conservation may offer us less information about the understanding of concepts than about how children attend. When children were presented many different examples of quantitative equalities and differences and were required to respond on the basis of these examples, they later performed effectively in tests of conservation. Their inadequacies were not in thinking, but in attending.

We know that in general attention is a prerequisite for learning. If the child is not attending to the material being presented it is impossible for learning to occur. What we may not be so aware of is the fact that attention must be directed specifically to those aspects of the situation that are critical for the solution of the problem. For the teacher, it is obvious what is relevant and what is irrelevant. We cannot assume, however, that what is relevant for the teacher will be the same things that attract the child's attention. What may appear to be poor conceptualization on the part of the child may simply be a result of the teacher's failing to insure that the problem has been presented in a way so that its critical features are highlighted for the child.

4. <u>Transfer is facilitated if the child has multiple examples of a rule over a wide range of extremes.</u> The goal of most teaching is to provide information that can be used appropriately in new settings. As such, we are interested in increasing the child's ability to transfer information from one context to another. We commonly teach the child a rule and then ask him to utilize the rule with new materials. This often is difficult for young children, and although they are able to learn the rule for solving the original problem, they approach the changed situation as if it posed a new problem and fail to apply the rule.

An example of this difficulty is evidenced in the behavior of young children in problems of transposition, where the child is asked to learn a relational rule and transfer it to new sets of stimuli. The child is taught to choose one stimulus from a set that differs in a property such as size. Original learning can occur in a trial-and-error fashion. Each time the child chooses, say, the middle-sized stimulus in a set of three, he is rewarded; choices of the smallest and largest stimuli do not lead to reward. When the middle-sized stimulus is chosen consistently the experimenter introduces a new set of stimuli that differ in absolute size from the training set but bear the same within-set relation. Young children have difficulty with this type of problem and fail to apply the rule they have just learned. Could they fail to demonstrate transfer, not because they did not learn the rule well, but because they fail to understand that a response learned in one situation is applicable to other situations? If this is the case, it should be possible to demonstrate to the child during original training that the response is not restricted to stimuli with certain absolute properties. Beatty and Weir (1966) have done this with three- and four-year-olds, children who typically have difficulty in transferring concepts such as largest, smallest, and middle-sized.

The stimuli were 16 squares with area-ratios of 1.3 to 1. Training was conducted with stimuli 4-5-6 and 14-15-16 (the squares are numbered from 1 to 16 in order of increasing size for convenience of description). The order in which the sets of stimuli were presented was random. This type of training should increase the child's understanding that a choice of intermediate size is appropriate over a broad range of stimuli. After they learned the correct response to the training stimuli, a new set, 9-10-11, was presented without comment. Would the children choose at random, or would their first choice be that of the stimulus of intermediate size? Over three-fourths of the children demonstrated transfer; they chose the stimulus of intermediate size.

This study offers an interesting insight into how we can increase the child's ability to transfer information. If the child is taught from the beginning that the same rule is applicable to widely divergent examples, we should increase the likelihood that the child will be able to use the rule in still different situations. We usually try to select similar examples for use during the child's first exposure to a problem in an effort to aid him in his original learning. This may have the unexpected effect, however, of restricting the child's ability to use the information in other situations.

5. Young children are easily distracted by the presence of irrelevant information. It is very difficult for us to see the world as it is perceived by young children. Vast amounts of experience have led us to be able to respond to critical features of our environment and to ignore those aspects that have no momentary significance. Young children do this only with difficulty; for them, incidental features of the environment may be as salient as those that have some importance to their lives. The ability to attend selectively, to categorize the environment

into what is critical and what is not, develops rather late; evidence indicates that not until the child is ten or twelve years old is he able to do this spontaneously. Before this, he can do it with help or special training. In designing materials for young children we run into a paradox. In an effort to make the material interesting unessential details often are included; scenes contain more than the central figures, workbooks vary the format on successive pages. The net effect is that the additional details introduced to heighten interest often act at the same time as distractors and lead the child to fail to attend to the central information that is being imparted.

I can illustrate this point by describing a study by Lubker and Small (1967) who presented third and fourth graders with an oddity task of the type described earlier. Manifestly, the problem was simple. All the child had to do was to choose the stimulus in a set of four that differed from the others in color. But in some cases irrelevant information was present. For example, the forms may have differed in brightness, size, or thickness. Adults would learn quickly to ignore the irrelevant information, for they could quickly ascertain that it was of no help in attaining correct response. For children, however, the presence of the irrelevant information acted as a distractor, and their performance suffered. Children tested with stimuli that contained one or two irrelevant dimensions performed only slightly above chance at the end of training. When no irrelevant dimensions were present, over 90% of the responses were correct.

We can make learning easier, therefore, by eliminating irrelevant information to as great a degree as possible, for young children have a hard time doing this by themselves. At the same time we can be helpful if we heighten the differences among stimuli by having them differ consistently in more than one respect. That is, while irrelevant information may be deleterious to learning, redundant information may be helpful. Learning to discriminate a large black square from a small white circle would be easy. Learning to discriminate a sqaure that sometimes was black and sometimes large from a circle that was black at times and large at times would be very difficult.

6. Language may be helpful, but it is unnecessary for abstract thought. An enormous amount of effort has been expended in attempts to understand the relation between language and abstract thought. Some view abstract thought as

a product of language, while others believe that the development of language and cognitive development are parallel but not interdependent processes. There is no question that language may be of help in conceptualization, but can concepts be learned and used without the intervention of language? For older children and adults it is nearly impossible to separate the two processes. Language is such a highly practiced skill that one can translate nearly all experience into words. Young children, however, are still in the process of learning language. Are there ways in which we could demonstrate that they are capable of abstract thinking, as exemplified in their correct application of certain concepts, but are unable to tell us how they solved the problem or to describe the concepts they employed?

We can use a study by Caron (1968) as a reference. Three-year-olds do not know words to describe the concepts of roundness or angularity. Furthermore, it is extremely difficult for them, without prior training, to utilize these concepts. Caron sought to develop pretraining experiences that might lead these young children to employ the concepts correctly. Many sets of figures were constructed in which the differentiating attribute was the roundedness or pointedness of a portion of the figure. The figures were paired in a discrimination problem, where correct choice was dependent upon the consistent selection of a figure that contained one of these characteristics. Some children had to pick the stimulus with a rounded portion consistently and others had to pick the stimulus with a pointed portion. For some of the children the figures were presented initially only in part. Rather than use the fully represented figure, only the portion of each figure that contained the distinctive attribute was visible. Very gradually, and over a long series of trials, the full figure was "faded" in. By making only the critical feature initially discernible, three-year-olds were able to learn the discrimination. They gave clear evidence of having used the concepts, but there was no indication that the concepts had been represented in language. The children could not tell the experimenter at the end of the study how they had solved the problem, nor could they pick out the "round" and "pointed" figures when they were directed to do so.

The same results were obtained with a different pretraining procedure. Other groups of children were asked to fit the stimulus figures into a hollow V. The figures with an angular portion fit into the V and the others did not. The child was to go through the stimuli, placing the figures that fit into one pile and those that did not into another. When the children later were required to learn the discrimination task they were highly successful. Again, they could not give a verbal explanation of how they solved the problem, and were unable to identify the figures that possessed the attribute described by the adult.

From studies such as this we are led to conclude that children are capable of using concepts they cannot verbalize. Especially during the early elementary years, when language still is undergoing rapid development, we may expect too much of children if we require children to be able to tell us how they solved a problem. Words are the natural means for transmitting knowledge among adults, but words are not always the most effective medium for instructing children. Classrooms are highly verbal environments. This may be why scores on the verbal portion of IQ tests are better predictors of school success than are scores on the nonverbal portions of the tests. Perhaps our classrooms in the early elementary years are too full of words. Learning may be aided at times if children are given greater opportunities to learn in other ways.

7. Children learn well through observation. In most formal learning situations the child is expected to act rather than to observe. We tend to think that we are not performing our functions effectively as teachers unless something is being actively taught, unless the child is making some form of verbal or motor response throughout the lesson. Each child is given a workbook, and is expected to learn through solving each successive problem. Or children come to expect that they are supposed to be learning while they solve problems at the board, and otherwise are to wait their turn passively. This is in direct contrast with what happens in everyday life. A significant amount of learning occurs in everyday life through the observation of the efforts of other persons in the home, at play, or on television. Children learn styles of dress by observing what other persons in their environments are wearing; they learn certain types of speech by hearing what other people have to say. Young children learn complex games by watching older children perform them. Active participation by the child is of great importance in producing many types of behavioral change, but we know that learning also can occur effectively through the observation of the behavior of other persons. In fact, in some cases learning through observation may be more effective than direct particpation.

We can use a study by Rosenbaum (1967) to illustrate many of the features of observational learning. An observer and a performer (children from grades one through six) were present in each experimental session. The performers solved 20 four-choice position discriminations in which one of each four positions was correct. They responded by inserting a stylus into holes of an 80-hole matrix (20 rows, 4 columns), and were required to locate the correct hole before proceeding to the next row. Both performers and observers then were given a printed duplicate of the matrix and asked to mark the position that was correct in each row.

The scores made by the observers were above chance at all grade levels. Observers demonstrated a significant degree of learning, even though their experience had been limited to viewing another person's efforts and the consequence of his response. Their scores not only were above chance, they exceeded those obtained by the performers themselves. Spared the chores faced by the performers of following directions, inserting the stylus at the correct times, remembering which holes had and had not been tried, the observers apparently were able to stand back and view the performer's efforts in a casual, but effective manner.

It is interesting that so much is made of how young children learn the wrong things and the wrong values by passively watching television, but at the same time so little concern is shown for the value of observational learning in the classroom. Eventually, of course, we must ask the child to perform, for otherwise we have no indication of how much he has learned. But during the acquisition process, especially in topics that may be difficult for some children such as mathematics, we could use observational learning in creative and constructive ways. Could not, for example, conditions be arranged so that during the early phases of teaching addition the child could learn through observation rather than solely through performance? Efforts to use games and educational materials in the classroom offer good opportunities for children to learn through observation of their own efforts and the efforts of others. Formal instruction that "a cube is a figure with six sides" or that "two one-fourths equals one-half" may cause young children much more difficulty than having an opportunity to observe the relations and to hear incidental verbalization of the definition.

8. Children utilize hypotheses, but their hypotheses may be inappropriate for the problem being presented. At one time we were led to believe that children

functioned pretty much in a stimulus-response manner. Get the response to occur in the presence of the relevant stimulus, reinforce the response, and learning will take place. According to this view, children are passive respondents to their environment, controlled by the contingencies between response and reinforcement. There is no doubt that we can exert a strong influence over what children learn and think when we have full control of the resources that are available to them, such as occurs in institutions, or when we are able to offer them their only access to highly desired rewards. In most everyday environments, however, we have fewer opportunities to exert this kind of influence.

Currently, a good many child psychologists view the child as an active participant in the construction of his environment, an individual who responds with hypotheses and expectations, preferences and biases. Children behave in a highly systematic manner, even at very early ages, and they appear to act on their environment and not merely respond to it. There are times in the classroom, however, when children do not seem to operate in such a sophisticated fashion. Their behavior appears to be uncomprehending and inappropriate, and it is easy to interpret this as being due to dullness or a lack of interest. Careful scrutiny of what the children are doing, however, may lead us to different conclusions. They may be responding in the best way they know how, developing hypotheses and strategies that to them seem to be reasonable avenues to successful performance. The problem may be that the hypotheses and strategies they devise are too simple or too complex for the task at hand.

I can illustrate this point with a study by Weir and Stevenson (1959), with children of ages three, five, seven, and nine. The children were required to discriminate the correct member of five pairs of pictures of common animals. Each pair of pictures appeared once in each block of five trials and a total of 140 trials were given. This is not a difficult task; and we would expect more and more rapid learning with increasing age. All the child had to do was to discover and remember which animal in each of five pairs was correct. For three-year-olds the problem should be difficult, and it was; only about half of their total number of responses were correct. Performance improved for children at age five. They were able to name the animals, and to use the names as cues for remembering which animal in each pair was correct. But at age seven performance dropped, and by age nine the children were making approximately the same number of correct responses as the three-year-olds. The problem had not changed, the children were older, but performance was unbelievably poor.

We could conclude that the older children were not paying attention, were uninterested in the task, or were an unrepresentative sample of nine-year-olds. None of these explanations seemed to hold up. The children did appear to be interested in the problem and evidenced disappointment when their choices were incorrect. Why, then, should they have performed so poorly? A cue to the basis of their difficulty was found in what they had to say at the end of the task, when they were asked how they had known which animal was correct. The older children made statements such as, "I thought it was going to be a pattern" or "I thought you were going to change them all around." They had formed complex hypotheses and these hypotheses had hindered their progress in reaching the simple, correct solution.

We can make erroneous interpretations about children's abilities if we do not take the time to investigate the basis of their mistakes. If they do not behave in accord with the way we think they should we may perceive them as being far less capable than they really are. As Frederick Lewis Allen once said, "I think that children are more intelligent and less experienced than most adults realize." We should seek ways in which their experiences can be used constructively in helping them to approach tasks in what we consider to be appropriate, intelligent ways.

9. Difficult problems can be solved more readily if they are broken down into successively more complex components. One of the great contributions of programmed instruction and behavior modification has been the demonstration of how complex problems can be mastered, often without error, if the problem is broken down into its components. Elementary components are presented first, and after each of these is mastered, successively more complex components are introduced.

Just as children make assumptions about what the teacher expects for an answer, teachers make assumptions about what children already know -- and in both cases the assumptions may be inappropriate. For example, we give children a problem in which they are to make judgments of "same" or "different" about geometrical figures. The children confuse squares and rectangles; circles and ellipses frequently are judged to be the same. We repeat the instructions, but errors continue. Finally, we realize that our request has been misinterpreted. The children have been defining "same" to mean similar, while we had meant identical. Had we attempted to analyse the task, we would have seen that our first step should have been to demonstrate what we meant by same and different. Once this step is understood, the problem becomes much clearer. This may seem to be a trivial example, but I use it to exemplify the importance of examining and checking our assumptions concerning what children know before proceeding to more complex problems.

Perhaps a better example comes from a study by Bijou (Bijou and Baer, 1963). If we were to observe performance during the later stages of this study we would find children of three to six making matching-to-sample responses that would be difficult even for adults. A complicated geometric figure appears at the top of a screen. The child is to choose a matching figure from five alternatives that differ in structure and in angle of rotation.

How were children this young brought to such a remarkable level of proficiency? Bijou broke the problem down into its simplest components and required that each step be understood before the next step was introduced. At first only a simple figure such as a circle appeared as the sample. Directly below it was a matching circle and appearing with the circle were a square and triangle. The identity of the sample and the correct alternative was emphasized by presenting simple geometric figures in close proximity. Gradually in successive trials the position of the match was moved from below the sample, the figure became more complex, and the number of choices increased gradually from three to five. The children proceeded through the training at their own pace, but in every case each problem was solved correctly before the next, slightly more difficult problem appeared.

Many other examples could be used, but the point is the same. We often can produce superior performance if we will identify the components of a task, present the components in successively more complex combinations, and assure ourselves that the child has mastered each of the steps. We make no assumptions about what the child is capable of doing until after he has demonstrated his level of competence. However obvious this may seem, it takes a study such as Bijou's to impress us with how much can be accomplished with this procedure.

10. <u>The relationship between teacher and child is an important determinant of the child's performance.</u> Every teacher faces a basic dilemma. With so little time and so much material to cove', how can the teacher worry about relating to each individual child? Is the teacher's primary responsibility to impart information and to teach skills, wih the building of positive interpersonal relationships an incidental, or less important goal? The answer, I believe, must always be no. The kind of relationship that exists between teacher and pupil will determine, in part, how much and how well the child will learn. Whatever effort is spent in developing sound teaching procedures can lead only to partial success unless the child perceives the teacher as a potentially interested and supportive person. This is especially true in teaching young children, for they have not reached the point where formal school material itself begins to be of sufficient inherent interest to insure persistent efforts to learn.

Many studies have demonstrated that the adult's effectiveness in influencing children's behavior depends upon he quality of the interaction. We know that children will try harder and learning will be aided if the adult rewards the child's efforts with praise or other forms of supportive response. But even praise may have differing degrees of influence, depending upon the role the adult establishes with the child. McCoy and Zigler (1965) have demonstrated this experimentally. An adult experimenter attempted to establish different roles with six- and seven-year-old boys. In a neutral condition the adult took the boys in groups of six to a classroom where they were given attractive art materials with which to work. She attempted to be as neutral as possible, keeping busy at her desk and attempting not to elicit bids for social interaction. In a positive condition the boys again were allowed to work with art materials, but the adult was diligent in her efforts to interact with each boy and tried to be complimentary, helpful, and responsive. Three sessions, held one week apart, were conducted in this manner. One week after the third session the boys played a game with the experimenter in which she made supportive comments about their performance twice a minute. The boys were allowed to play the game as long as they wished.

Some boys played the game after no prior interaction with the adult. The boys for whom the adult was a stranger terminated the game after an average of 2.5 minutes. When the experimenter had behaved in a neutral manner in the earlier sessions the boys remained at the game for an average of 9.6 minutes, and when she had interacted positively with the boys they remained for an average of 13.4 minutes.

There are other studies showing that adults differ greatly in their ability to influence the behavior of young children and that these differences increase as children grow older. Other studies offer examples of how adults can be trained to adopt roles that reduce these differences. In general, adults can heighten their effectiveness with children if they are enthusiastic, involved, and responsive. The critical, punitive, aloof adult may be effective in some situations, but rarely is it in interacting with young children. Much of the motivation of young children to learn subjects such as mathematics depends upon the human factor -- children work in part to please the teacher. Ideally we hope for situations where learning is directed by the interests of the child, but in the early years these interests usually are not developed sufficiently to direct the child without a teacher's enthusiasm and encouragement.

These are some of the ideas that can be derived from recent research on children's learning and thought. Undoubtedly, a great many more could be developed. It has been necessary here, because of limited space to present the ideas in skeletal outline; further information about research in children's learning may be found in Stevenson (1972) and on children's cognitive development in Flavell (1970) and Rohwer (1970). In the future we can hope that there will be closer linkages between psychological research with children and education. From such mutual efforts it should be possible to develop a sound scientific basis for teaching practices.

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